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MS 1265-6 (2005) (English): CODE OF GOOD
IRRADIATION PRACTICE - PART 6: BANANAS, MANGOES
AND PAPAYAS FOR SHELF-LIFE EXTENSION (FIRST
REVISION)



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MALAYSIAN STANDARD

MS 1265: PART 6:2005

CODE OF GOOD IRRADIATION PRACTICE – PART 6: BANANAS, MANGOES AND PAPAYAS FOR SHELF-LIFE EXTENSION (FIRST REVISION)

ICS: 67.020

Descriptors: code of practice, irradiation, ionising, radiation treatment, banana (*Musa spp.*) mango (*Mangifera indica* L.), (*Carica papaya* L.), shelf-life extension, delay ripening

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Committee representation

The Food and Agricultural Industry Standards Committee (ISC A) under whose authority this Malaysian Standard was developed, comprises representatives from the following organisations:

Department of Agriculture
Department of Standards Malaysia
Federal Agricultural Marketing Authority
Federation of Malaysian Manufacturers
Malaysian Agricultural Research and Development Institute
Malaysian Palm Oil Association
Malaysian Association of Standards Users
Ministry of Agriculture and Agro-based Industry
Ministry of Health Malaysia
Ministry of International Trade and Industry
Universiti Kebangsaan Malaysia
Universiti Putra Malaysia

The Working Group on Food Irradiation which developed this Malaysian Standard consists of representatives from the following organisations:

Department of Fisheries Malaysia
Department of Veterinary Services Malaysia
Federation of Malaysian Consumers Associations
Malaysian Agricultural Research and Development Institute
Malaysian Institute for Nuclear Technology Research
Ministry of Health Malaysia
SIRIM Berhad (Secretariat)
Universiti Putra Malaysia

FOREWORD

This Malaysian Standard was developed by the Working Group on Food Irradiation under the authority of the Food and Agricultural Industry Standards Committee.

MS 1265 consists of the following parts, under the general title *Code of good irradiation practice*:

- Part 1: *General*
- Part 2: *Bulb and tuber crops for sprout inhibition*
- Part 3: *Fresh fruits and vegetables for insect disinfestations and as quarantine treatment*
- Part 4: *Cereal grains for insect disinfestations*
- Part 5: *Dried fish and dried salted fish for insect disinfestations*
- Part 6: *Bananas, mangoes and papayas for shelf-life extension*
- Part 7: *Fish, frog legs and shrimps for the control of microflora*
- Part 8: *Prepackaged meat and poultry for the control of pathogens and/or to extend shelf-life*
- Part 9: *Spices, herbs and vegetable seasonings for the control of pathogens and microflora*
- Part 10: *Dried meat and dried salted meat of animal origin for insect disinfestations, control moulds and reduction of pathogenic microorganisms*

This Malaysian Standard is the first revision of MS 1265: Part 6, *Guidelines for irradiation of foods: Part 6: Irradiation of bananas, mangoes, and papayas for shelf-life extension (by delay of ripening)*.

Major modifications in this revision are as follows:

- a) new radiation source has been added; and
- b) the labeling requirements have been revised.

This Malaysian Standard cancels and replaces MS 1265: Part 6:1992, *Guidelines for irradiation of foods: Part 6: Irradiation of bananas, mangoes, and papayas for shelf-life extension (by delay of ripening)*.

Compliance with a Malaysian Standard does not of itself confer immunity from legal obligations.

**CODE OF GOOD IRRADIATION PRACTICE –
PART 6: BANANAS, MANGOES AND PAPAYAS FOR SHELF-LIFE
EXTENSION
(FIRST REVISION)**

1. Scope

1.1 This Malaysian Standard describes the code of good irradiation practice for the following fresh tropical fruits (including their varieties and cultivars); banana (*Musa spp.* and *hybrids*), mango (*Mangifera indica* L.) and papaya (*Carica papaya* L.).

1.2 The purpose of irradiation of banana, mango and papaya fruits is to extend the normal shelf-life by delaying their ripening. Other possible effects of irradiation, such as reduction of spoilage microorganisms or insect disinfestations, may be secured, but are not the primary purpose of irradiation, as covered in this standard.

2. Normative reference

The following normative reference is indispensable for the application of this standard. For dated reference, only the edition cited applies. For undated reference, the latest edition of the normative reference (including any amendments) applies.

MS 1265: Part 1, *Code of good irradiation practice - Part 1: General*

3. Pre-irradiation treatment of fruits

3.1 General

3.1.1 Initial quality

3.1.1.1 Fruits to be irradiated should be freshly harvested, sound, clean and free of any mechanical injury or physiological disorder, and without indication of microbial spoilage or insect infestation. The irradiation treatment will not improve the quality of fruit if it is of poor quality and damaged due to poor handling. Wherever possible, fruits should be harvested under dry conditions and during the coolest part of the day to minimise cause of field heat. The crop should be aerated to remove heat absorbed in the field as soon as possible. The fruits should be carefully picked and handled to reduce mechanical damage.

3.1.1.2 Bananas, mangoes and papayas are climacteric fruits and should be harvested at the hard mature green state. The decline in the respiratory rate is indicated by the decrease of carbon dioxide production and oxygen consumption. On continued storage of the fruit, ripening begins and the rates of respiration and ethylene production increase. The fruit is in the process of ripening when changes such as softening and colour changes occur. The respiration and ethylene production rates will reach its peak, and at or immediately after this stage the fruit is considered ripe.

3.1.1.3 The fruits should be harvested at the suitable maturity stage and ripened upon arrival at their destination markets. The irradiation of fruits for the purpose of delaying their ripening should be done when the fruits are harvested at the hard mature green state and before starting their climacteric changes.

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3.1.1.4 Irradiation conducted after the climacteric stage has begun will not delay the ripening period of the fruit but may even accelerate it. However, irradiation at a too early stage may prevent normal ripening from occurring (see 3.2, 3.3 and 3.4).

3.1.2 Fungal control

3.1.2.1 Bananas, mangoes and papayas are subject to fungal decay. The irradiation treatment to control fungi requires doses could be phytotoxic. Therefore, in order to control spoilage due to fungi by irradiation treatment, these fruits are to be given a pre-irradiation treatment with hot water. For example; papayas - 20 min at 49 °C or 10 min at 50 °C; mangoes - 10 min at 50 °C or 5 min at 55 °C; bananas - 5 minutes at 50 °C. An approved chemical fungicide may be added in the water may be beneficial.

3.1.2.2 If wax treatment is given, it is done after the hot-water treatment. Fruits should be thoroughly dried before irradiation in order to prevent damage to its skin.

3.2 Bananas

3.2.1 Bananas are harvested in the hard green state. The green pre-climacteric storage life depends to a large extent on harvest maturity; fruits harvested at an earlier stage of maturity can be kept longer than those harvested at a later stage of maturity. There is no sure and practical way of determining maturity and exporters rely mainly on fruit diameter and angularities. The fullness of a banana is not always indicative of maturity as fruits borne from diseased or undernourished plants can be lean in size but well advanced in maturity. When good agronomic practices are followed, a combination of chronological age of the fruit, i.e. the time elapsed between inflorescence emergence (shooting) and harvest, and fullness of the fruit normally gives a reliable indication of fruit maturity.

3.2.2 The irradiation of immature bananas is to be avoided as such fruits fail to ripen normally and may result in a poorer flavour.

3.2.3 Bananas are deheaded, graded, washed to remove floral ends, dirt and latex, and dipped in an approved fungicidal solution to prevent decay of the crown tissue. Hands may be further separated into clusters of five to six fingers depending upon local practices and packaging requirements. Latex from the cut surface should be allowed to exude prior to the final packaging operation. A fungicidal paste is normally applied to seal off the cut surfaces to reduce the shrinkage of crown tissue and entry of spoilage fungi.

3.3 Mangoes

3.3.1 Mangoes are normally picked at the mature green stage. The stage of maturity at harvest is of critical importance, since immature fruits tend to be inferior in sweetness, flavour and aroma on ripening, and also tend to shrivel at a faster rate than fully mature ones.

3.3.2 There is no uniform method available to assess the maturity of the fruit since the criteria useful for one variety may not be valid for another. Generally, harvesting is based on size, shape and colour of fruits. Maturity in many varieties is indicated by a uniform olive green skin colour, and outgrown shoulders with a shallow sunken area around the fruit stalk. The specific gravity of the fruit may be used as an index of maturity; fruits with specific gravity above 1.0 will subsequently ripen with a good flavour. The change in flesh colour from greenish yellow to yellow is a dependable maturity index but is destructive unless light transmission methods are used. The normal practice is to harvest mangoes in a very early stage of maturity in order to reach the market in a good condition, especially at the beginning of the season when prices are high.

3.3.3 The irradiation of immature mangoes should be avoided, as this may result in uneven ripening and increased shrivelling.

3.3.4 Mangoes should be clipped leaving only a small portion of the stalk, graded and cleaned to remove latex before packaging. If hot water treatment and waxing are to be combined with the irradiation treatment then the fruits should be thoroughly dried prior to packaging and irradiation.

3.4 Papayas

3.4.1 Papayas are normally harvested based on their size and colour. Commercially, fruits are picked according to one of the following colour grades depending on the length of time required for the papaya to reach the market destination:

- a) mature-green to "blush" of yellow colour of the intercarpel grooves of the surface at the blossom end. (It is difficult to determine the differences between colour break and mature-green. Commercial packing operators consider this as the mature-green stage. In some markets, fruits are marketed as early as the mature-green stage when the flesh is white and latex is present).
- b) "blush" to definite yellow colour on approximately 1/4 of the blossom end and surface (Colour develops along the intercarpel grooves from the blossom end. This stage is considered 1/4 colour in commercial practice).
- c) definite yellow colour on 1/4 to approximately 1/2 of the surface. (This is considered as 1/2 colour in commercial practice).
- d) definite yellow colour on 1/2 to 3/4 of the surface. (This is considered as 3/4 colour in commercial practice and will have a distribution and market shelf-life of at least seven days at 30 °C).
- e) definite yellow colour on 3/4 to virtually the total surface. (This is considered as full colour in commercial practice and market shelf-life limits the distribution to local markets).

4. Packaging

4.1 General

4.1.1 The packaging material in contact with the fruits covered by this standard should not undergo any significant alteration of its functional properties nor yield toxic materials which can be transferred to the food, as a result of irradiation at the doses employed.

4.1.2 The containers currently used commercially for packaging of tropical fruits are suitable to be use with the irradiation treatment.

4.1.3 Containers made of wood or other cellulose material may gradually be damaged and eventually will become unusable if exposed repeatedly to irradiation.

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4.1.4 The size and shape of containers which may be used for irradiation are determined according to certain aspects of the irradiation facility. The critical aspects include the characteristics of the product transport systems and the irradiation source, as both relate to the dose rate distribution to the container (see Clause 6).

4.1.5 The irradiation treatment will be more effective if the product packages are geometrically well-defined and uniform. It may be necessary to limit the use of certain package shapes and sizes to the requirements of certain irradiation facilities.

4.2 Bananas

The hands or clusters surface should be dried and packed in fibre board boxes. The size of the containers may vary according to local practices and export requirements. Bananas are a very delicate fruit, therefore every effort should be made to minimise abrasion due to rubbing of the fruit. Polyethylene film liners may be used to prevent abrasion due to contact with the box material.

4.3 Mangoes

The wrapping of individual fruits with tissue paper and use of fibre board gives the best protection to the fruit during transportation and handling. The use of polyethylene film liners is not advisable, as mangoes are very sensitive to increased CO₂ levels which may affect the quality on ripening. Irradiation can be performed with the fruit in the package.

4.4 Papayas

The fruits are individually wrapped in clean white paper and packed in fibre board or wooden containers with wood wool as a packing material. Hot-water treated fruits should be dried well before wrapping and packing in containers. The container size may vary depending on the range of the fruit size. Irradiation can be performed in the package.

5. Pre-irradiation storage and transport

5.1 Irradiation should be carried out as soon as possible after harvesting of bananas, mangoes and papayas. If a hot-water treatment is required prior to irradiation (for disease control), the irradiation should be carried out immediately after the hot-water treatment and thorough surface drying of the fruits. Delays between hot-water and irradiation treatments should be kept at a minimum time. If storage between harvest and irradiation is required then the fruits should be kept at their optimum storage temperature and relative humidity to avoid chilling injury. Chilled fruits are often much more susceptible to irradiation injury.

6. Irradiation

6.1 Facility requirements and operation; process parameters and critical operational control points; ionising radiation sources employed

6.1.1 The requirements and guidance regarding certain irradiation process parameters and irradiation facilities and their operations should be referred to MS 1265: Part 1.

6.1.2 The ionising radiation which may be used for the irradiation of the fresh tropical fruits is limited to:

- a) Gamma rays from the radionuclides Cobalt-60 and Caesium-137;
- b) X-rays generated from machine sources operated at or below an energy level of 5 MeV (Million Electron Volts); and
- c) Electrons generated from machine sources operated at or below an energy level of 10 MeV.

6.1.3 The selection of the irradiation source to be employed in the treatment should be appropriately considered, for example the use of electrons has its limitations due to their poor penetration ability.

6.1.4 It is not possible to distinguish irradiated from non-irradiated product by inspection. Therefore, it is important that, in the operation of an irradiation facility, any appropriate means, such as physical barriers, be used for keeping the irradiated and non-irradiated product separate.

6.1.5 Indicators which change colour or which otherwise undergo some easily determined and time-stable change when exposed to radiation at the doses required are commercially available. Such devices, common in the radiation-sterilisation industry which is used as a paper sticker (or equivalent) and attached to each product unit, such as a carton, could assist the operator in identifying irradiated product.

6.1.6 It is important to keep adequate records of the operation of the irradiation facility. Fruits which have been irradiated should be identified by lot numbers or other suitable means. Such measures which enable verification of the irradiation treatment carried out are likely to be required by the regulatory agencies

6.2 Amount of radiation used (absorbed dose)

6.2.1 General

6.2.1.1 The most important process parameters in the irradiation treatment of food is the amount of ionising energy absorbed by the target material. This is termed 'absorbed dose'. The unit of absorbed dose is the Gray (Gy). One Gy is equal to the absorption of one joule per kg. The dose employed is determined by the level of the initial contamination (number of insects), the kind of insects, and the purpose of the treatment.

6.2.1.2 The irradiation procedure is controlled to deliver a prescribed dose involves a number of considerations. Among which is important is the technology for measuring dose, given the termed 'dosimetry'. The manuals on dosimetry procedures should be consulted. Refer to bibliography for the list of references on dosimetry procedures.

6.2.2 Bananas

Generally absorbed doses in the range of 200 Gy to 400 Gy are suitable for delaying the ripening of pre-climacteric bananas. The particular absorbed dose that is effective varies with the variety. The maximum delay of ripening occurs in fruits of lower maturity at harvest. Almost all varieties that have been tested do not tolerate absorbed doses exceeding 500 Gy when irradiated in the pre-climacteric state. Excessive amounts of radiation can cause changes in physical characteristics, such as skin colour and integrity, or pulp texture.

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6.2.3 Mangoes

Absorbed doses effective in inhibiting ripening of mangoes, irradiated in the hard green pre-climacteric state, are greatly dependent upon the variety of mango and the production area. It is necessary to establish the dose requirements for each variety for the local conditions. Absorbed doses may be expected to fall in the range of 250 to 750 Gy. Higher doses may be detrimental to the fruit quality.

6.2.4 Papayas

Absorbed doses in the range of 750 Gy to 1000 Gy given to papayas in the pre-climacteric state are effective. Absorbed dose above 1500 Gy may cause changes in physical characteristics, such as scalding of the skin.

6.3 Irradiation conditions

6.3.1 The irradiation area should be well ventilated in order to prevent ozone build-up. ozone can be phytotoxic to some fruits. Extra care should be taken for fruits which have been stored under refrigeration in order to prevent condensation of moisture on the fruit, which may result in phytotoxicity. For example, mangoes irradiated while still cold and with condensed moisture on them will become discoloured.

6.3.2 It is essential to ascertain dose distribution patterns within any container, to ensure that the minimum absorbed dose achieves its purpose while the maximum absorbed dose is not phytotoxic.

7. Post-irradiation handling and storage

7.1 Generally most tropical fruits undergo 'chilling injury' when stored at low temperatures. The extent of delay of ripening caused by irradiation is partly determined by the storage temperature, being less at higher temperatures. Optimum temperatures for post-irradiation storage and handling, therefore, are in general those as low as possible but which do not cause 'chilling injury'.

7.2 The following temperatures are suggested with relative humidity of 90 % – 95 %:

- a) Bananas - 13 °C - 15 °C;
- b) Mangoes - 11 °C - 13 °C; and
- c) Papayas - 15 °C - 16 °C.

7.3 Irradiated fruits are often more susceptible to chilling injury than non-irradiated fruits. However, storage at ambient temperatures during the last several days of the product life is satisfactory.

8. Labelling

8.1 Foods that have been irradiated shall be labelled and labelling shall be in accordance with the current national legislation requirements.

8.2 Labelling should not only identify the food as irradiated, but also serve to inform the purchaser as to the purpose and benefits of the treatment.

8.3 Each package containing the food treated by ionising radiation may bear on it the international food irradiation symbol given in MS 1265: Part 1.

9. Re-irradiation

Irradiation of the same product more than once is not recommended. Re-irradiation of bananas, mangoes and papayas would serve no useful purpose. MS 1265: Part 1 may be referred for provisions for irradiation of certain foods.

10. Quality of irradiated bananas, mangoes and papayas

10.1 Chemical changes

The irradiation of bananas, mangoes and papayas at doses below 1 kGy may cause only minor and insignificant chemical changes. Very little loss of vitamin C content occurs and it is not nutritionally significant.

10.2 Bananas

Bananas generally irradiated to delay ripening and ripened without or with the use of exogenous ethylene, have sensory properties comparable with non-irradiated ripe bananas. With certain varieties it has been observed that, although fully ripe as judged by skin colour, the bananas were not fully ripe as judged by taste test. Bananas given a heat-irradiation combination treatment are comparable with untreated bananas in their quality when ripe.

10.3 Mangoes

Irradiated mangoes generally have acceptable sensory characteristics. Mangoes given a combination heat-radiation treatment, e.g., 5 min in 55 °C water for disease control and 250 to 750 Gy, likewise are satisfactory and ship well.

10.4 Papayas

Irradiated papayas have acceptable sensory characteristics. Papayas given a combination heat-radiation treatment, e.g., 20 min in 49 °C water for disease control and 750 to 1000 Gy, are satisfactory and ship well.

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